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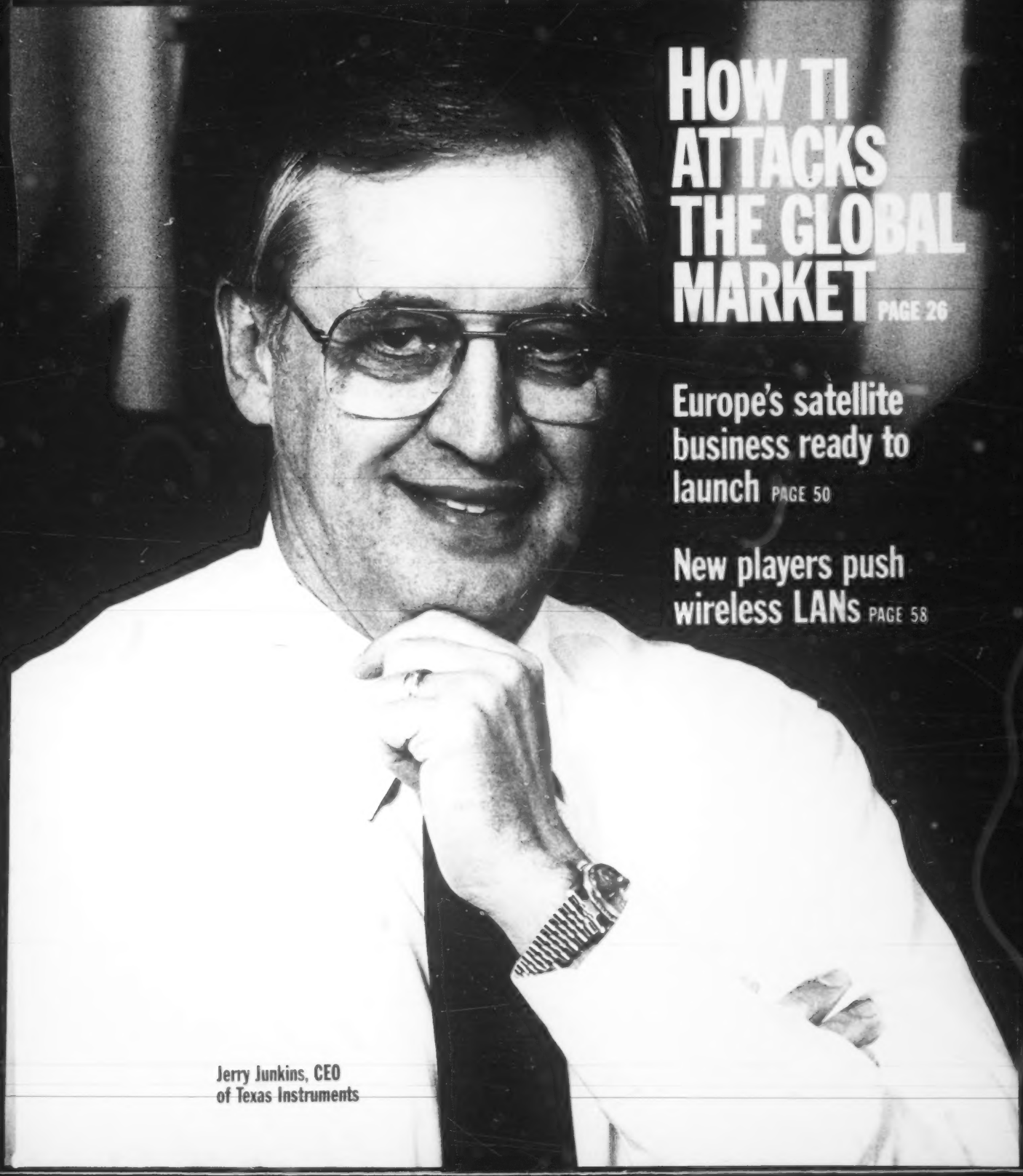

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Jerry Junkins, CEO of Texas Instruments

Electronic Business

FOR MANAGEMENT IN ELECTRONICS, COMPUTER, AND SYSTEMS COMPANIES—WORLDWIDE

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Changing one's image is never easy to do, but that's the challenge facing Texas Instruments. After much soul-searching, CEO Jerry Junkins has embodied a long-term vision known as TI 2000, which will help his company transform itself from old-guard to cutting-edge

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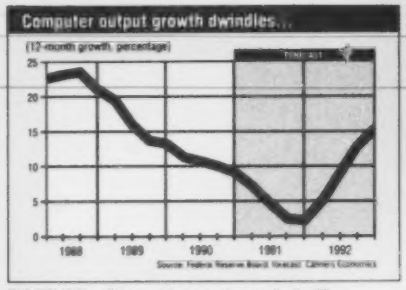

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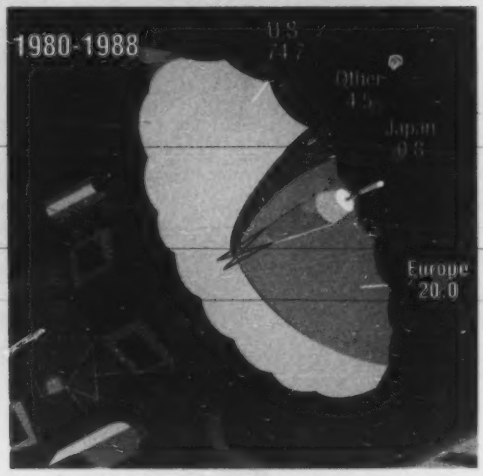

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Taking the long-term view

In this business there are a number of major players—and a lot of not-so-major players—that we keep close tabs on. One of the biggies is Texas Instruments. During the course of any given year the editors of ELECTRONIC BUSINESS will sometimes visit TI at its home base in Dallas, sometimes at its European headquarters in France.

CEO Jerry Junkins (left) with associate editor Peter Burrows

Our most recent visit with CEO Jerry Junkins and several of his colleagues happened to be near our own editorial offices. Managing editor Garrett DeYoung, senior editor Rick Whiting, associate editor Peter Burrows, and I spent several hours with Junkins, executive vice-president of the defense systems group Hank Hayes, and vice-president of investor relations Max Post for a wide-ranging discussion of the electronics industry in general and TI's strategies in particular.

We'd known for some time that TI had developed a plan known as TI 2000, a series of strategies destined to guide the company to the year 2000. The plan focused on three questions: Where is the world going? What is TI's position in that world? How do we plan to get there? Three key questions that any major electronics company ought to be asking as we plow into a decade that promises to be much tougher than the '80s.

It was a refreshing change to hear a CEO and his colleagues talk about a vision for the decade. Junkins is aggressively pursuing innovative financing and protecting the company's intellectual property, particularly in the area of semiconductors, a core business for TI. Just how *is* TI going about its future business? Read Peter Burrows's cover story on page 26.

As Burrows was rushing off to Texas to cover the story, senior editor Elizabeth Baatz was poking around closer to home reporting on the unsettled outlook for New England's battered electronics and computer industry. Once the centerpiece of the "Massachusetts miracle," the companies on Boston's Route 128 are struggling to overcome a sluggish economy and to keep up with rapid changes in technology. Many companies in the Northeast have never had the long-term vision of a TI 2000 and are now regretting it.

All is not gloom and doom however. As we reported in our Mar. 4 issue, many electronics companies are beating the recession. And Elizabeth singles out four New England companies that are likely to boom as the economy gathers steam. Indeed, New England as a whole may benefit now that companies have tightened their belts and become more streamlined. Stay tuned.

JEFFREY BAIRSTOW, editor

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VBPA ABP

SEMICONDUCTOR TRADE

A "single industry voice" gets results in chip wars

AFTER YEARS of bickering about how to stem allegedly unfair Japanese trade practices in semiconductors, America's chip and computer makers have forged a common vision. That vision, which was recently set forth by the Semiconductor Industries Association and the Computer Systems Policy Project, seeks to extend the 1986 semiconductor trade agreement between the U.S. and the Japanese governments. The agreement lapses in July.

The proposal conceals a number of compromises. For one, U.S. chip customers agree to extend through 1992 the target of a 20% share of the Japanese market for American chip suppliers; in the past, chip customers have feared that such "managed trade" policies could cause Japanese suppliers to pull back on production, thus limiting supplies of key components. For their part, chip makers—while still spooked by memories of the dumping that chased six of the eight U.S. DRAM makers out of business in the mid-1980s—agree to toned-down antidumping measures: Rather than authorize the U.S. Department of Commerce to set company-by-company price floors for imported commodity chips, the new plan takes government out of the loop until a complaint is filed.

"We have held divergent views [with the semiconductor industry] on many semiconductor trade issues," says Rod Canion, CEO and president of Houston-based computer maker Compaq Computer Corp. "But we realized a couple of years ago that arguing was not going to get us anywhere in Washington. We had a lot of common goals, and we decided to focus on those instead of on our differences."

For now, the new cooperation is playing well in Washington. Just weeks after the SIA/CSPP proposal was announced last October, members of the U.S. Trade Representative's office and the Commerce Department started negotiations with their counterparts in Japan's Ministry of Foreign Affairs and Ministry of International Trade and Industry. Since late January, there have been meetings roughly every two weeks between these bodies, says USTR spokesman Tim Richards, and the U.S. position has reportedly stuck close to the industry proposal.

"The industry consensus is almost unheard of," says Richards, "and it makes our job much easier." He points out that a single industry voice takes away a favorite negotiating ploy by the Japanese—playing off the interests of one industry sector against those of another.

Congress, which has yet to take a role in what has been a government-to-government gentleman's agreement, is also sounding bullish about the proposal. With anti-Japanese sentiment on the rise due to Japan's lack of military support for the Gulf effort and continued intransigence in the GATT talks and other trade issues, many lawmakers seem to have forgotten their fear of appearing to be in favor of "industrial policy." "We're certainly not in the business of picking winners and losers," says International Affairs Committee chairman Lloyd Bentsen (D-Tex.). "But there are some things that government can do."

Even Japan seems to be responding favorably. Although Japanese officials have opposed the extension on the grounds that progress is already being made, U.S. negotiators reportedly have been surprised at their willingness to talk—perhaps because the tone of the new proposal is less confrontational than the original version. "I expect the Japanese see this proposal as a reasonable way to get rid of some problems that aren't going to go away by themselves," says Canion.

PETER BURROWS

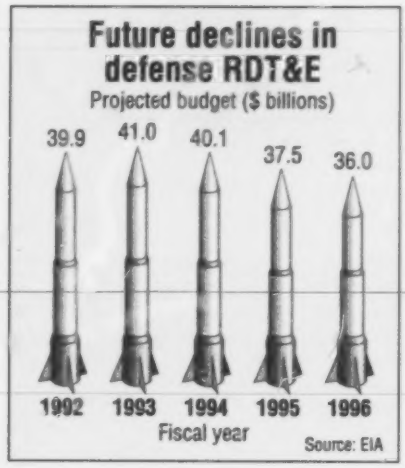
Compaq's Rod Canion and TI's Jerry Junkins, setting aside past computer/chip maker differences, in March brought a common vision for U.S.-Japan trade before Congress

DEFENSE

EIA sees decline in defense R&D spending

A PROJECTED decline in Department of Defense R&D spending is raising questions among defense electronics company executives about the future of the U.S. military's technology base.

The Electronic Industries Association predicts that the DOD budget for research, development, test, and evaluation (RDT&E) will begin to shrink in fiscal 1994. RDT&E, which totals $34.6 billion this fiscal year, is used to fund the development of



new electronics and weapons systems for the military, ranging from the smallest radiation-proof semiconductor to the B-2 Stealth bomber.

For fiscal 1992 the DOD is seeking from Congress $39.9 billion for RDT&E, an increase of 11.3% when adjusted for inflation. Increased spending for the Strategic Defense Initiative ("Star Wars") and the Advanced Tactical Fighter program account for much of the increase.

But RDT&E is expected to be only $41 billion in fiscal 1993—a real increase of only 0.9%—and is expected to shrink each year after that. Coming so soon after the Persian Gulf war, where high-tech weaponry proved so successful, the EIA predictions are setting off alarms.

At a recent Washington seminar, Geoffrey K. Bentley, business research manager for Textron Defense Systems, warned that the number of companies participating in military R&D is shrinking and threatens to erode the nation's technological edge.

Among the proposed remedies: Allow defense contractors to make a profit on R&D efforts. Now when defense companies sink huge sums of money into R&D, they are gambling that they will win big procurement orders from the Pentagon. Making money on the research itself—and thus reducing the gamble—will encourage more research, said C. M. Herzfeld, director of research and engineering at the DOD. "Industry can no longer subsidize R&D on projects that may never get built," he said.

But Herzfeld, who in essence is the Pentagon's chief technology officer, also issued a challenge to defense contractors. "I think RDT&E is here to stay," he said. "That's the good news. But it will change. What you want to do is look for the opportunities instead of crying about shrinking budgets."

RICK WHITING

SOFTWARE

A real market emerges for real-time systems

A MARKET for hardware-independent real-time operating systems (which permit computers to respond instantaneously to user commands) is blossoming for a handful of companies whose sales could skyrocket if their expectations materialize.

Makers of single-board computers and products with embedded microprocessors appear to be turning away from hardware-dependent and in-house real-time code to buy from companies such as Wind River Systems Inc., Ready Systems Corp., and Microware Systems Corp., which develop commercial real-time software.

"It's a $750 million market that could go to $1 billion next year," says Mitch Bishop, Wind River's director of marketing. "The reality is that real-time is arriving in the real world as an emerging marketplace."

Bishop says his Alameda, Calif.-based company's growth will double from $8 million in annual revenue for fiscal 1991 (ended Feb. 1) to $16 million next year. "There are a number of factors affecting that growth," he says. Traditionally, companies have built their own hardware and real-time operating systems but now want to get away from the hassles of redoing code every time new hardware is added. "They want shrink-wrapped software that will work on Intel, Motorola, or Sparc chips, not just a single architecture," he explains.

Wind River's Bishop: The real-time software systems market could reach $1 billion

Privately held Ready Systems in Sunnyvale, Calif., is the largest independent company in the market, with Microware of Des Moines a close second, and Wind River third. Dataquest analyst Doug Crook says that while it's difficult to determine the actual size of the real-time market, it's at least a $500 million market on the software side. "Last year we determined $1.3 billion went into real-time hardware, and operating systems are a component of that," he says. "It's a good strong niche market that an $8 million company can make money in."

DAVE WEBB

MULTIMEDIA

Multimedia: standards, but few products

MULTIMEDIA computers, whose bags of tricks include sound, animation, still images, and, in some cases, full-motion video, have yet to make much of a dent in the marketplace. But their potential impact could be huge, and vendors have been jockeying for years to ensure that they are positioned to exploit the market.

That activity has heated up in recent months. In March Microsoft Corp. of Redmond, Wash., announced that 11 hardware manufacturers had signed on in support of the software company's Multimedia PC (MPC) specification. Computers bearing the MPC mark would contain a 286 or a 386/486 microprocessor, 2 megabytes or more of random access memory, a 30-MB or larger hard disk, a 4-bit or 8-bit VGA video display, a digital audio subsystem, and a CD-ROM drive. They also would be compatible with Microsoft's Windows 3.0.

The MPC standard was seen in some quarters as a power grab by Microsoft, and one that was being coun-

the same time the EC is telling them their competitiveness rests in their own hands.

But ICL's ousting obviously doesn't mean that Jessi (within which IBM contributes to two projects) is cold to the idea of U.S. participation. In fact, Jessi officials long have privately called the consortium an "anti-Japanese" initiative.

This latest EC electronics policy presents no new initiatives and releases no additional EC funding. But it endorses the 12-member countries' funding of the European Nervous System, a proposed computer linking of EC public databases that is meant to increase demand for computer products and should be open to bids from U.S. companies. Redirection of funds is also a recommendation included in the new directive.

BARBARA BERKMAN

OPTICAL DRIVES

IBM could spur optical-drive market

IBM MAY BE positioning itself to give the optical-drive market a much-needed shot in the arm. Big Blue has recently been showing a 128-megabyte 3.5-inch form factor magneto-optical (MO) disk drive, which analysts expect the company will offer with its next PS/2s.

The erasable optical drive market has been slow to emerge, and the jury is still out as to whether OEM systems vendors will adopt the devices as complementary storage alternatives to magnetic disk drives. But if IBM makes such a move, other OEMs may follow suit, pushing demand beyond the threshold that has kept vendors confined to low-volume captive and distribution markets.

"IBM has demonstrated a considerable interest in optical-drive technology," says Nicos Syrimis, senior marketing manager for Cirrus Logic Inc.'s mass storage unit. "This is what is really needed—one of the big guys coming along and adopting it to provide leadership. If IBM does follow through and backs it, that'll certainly give the market credibility."

For now, Hewlett-Packard and Next Computer Inc. are the only systems vendors shipping workstation systems with MO drives. Those drives are 600-MB 5.25-inch form factor devices, not 3.5-inch drives, and are being used in applications the 3.5-inch drives can't handle.

"It's engineering workstation networks where you'll see [5.25-inch drives] showing up in any volume," says Jim Porter, president of Disk/Trend. "I fully expect companies such as Sun to use the 5.25-inch drives someday."

But the 3.5-inch models are being pegged to PCs. The other known vendor shipping OEM-bound 3.5-inch drives is Nakamichi Corp. of Japan. Porter says most of the Japanese vendors now shipping 5.25-inch drives all have 3.5-inch programs in the works but are likely to wait and see what happens to the market.

DAVE WEBB

FINANCIAL REPORTING

New guidelines for software sales?

JUST WHEN IS a software sale considered a sale? That question is usually relegated to the esoteric world of accounting, but the answer could mean millions of dollars for software vendors' revenue statements.

Under generally accepted accounting principles (GAAP), a sale can be listed on a company's books as revenue—specifically, an "account receivable"—only when the sale is a virtual certainty. But such standards are hazy when applied to the software industry. Customers, for example, may contract to buy a supplier's software one day, pay a license fee sometime later, and get the software up and running later still. Often products are not even "shipped" in the traditional sense; they may be transferred via phone lines. Further muddying the waters is when to account for revenue and expenses relating to training, maintenance, warranties, and upgrades—all major parts of the software business.

The result is that some software companies have been a bit too aggressive in counting *potential* sales as revenue, thus inflating their accounts receivable. In 1990, for example, database software vendor Informix Software Inc. listed 60% of its sales as accounts receivable because it counted a signed contract as a sale, rather than waiting until the license fee was paid.

All this has drawn the scrutiny of the federal Securities and Exchange Commission. To try and bring order to this chaos, the American Institute of Certified Public Accountants and Financial Accounting Standards Board have drafted accounting standards for the software industry. The 32-page proposed guidelines are now being circulated.

Adapso, a computer software and services industry association, and the Arthur Andersen & Co. accounting firm held forums on the proposed standards during March and April. The draft guidelines appear to have wide support, although some executives have proposed changes in sections dealing with software maintenance and other items. The AICPA comment period ends May 16.

But it is virtually certain the guidelines will be in effect by year's end. The SEC is already requiring newly registered software companies to abide by the guidelines. "If you are budgeting or planning for next year," Arthur Andersen's Richard Dieter said during a March 25 forum in Newton, Mass., "you must assume that this will become reality by late 1991."

One company taking such advice to heart is Informix. In January the company restated its 1990 income to comply with the more conservative accounting principles. The result: A $23.3 million accounting adjustment in the fourth quarter, and a loss for the year.

RICK WHITING

An unsettled outlook for New England electronics

Battered by declining defense spending and a national recession, the region looks to start-ups for revitalization

BY ELIZABETH B. BAATZ

In January 1990, Ted Eaton fell victim to the recession. Laid off from his position as New England sales director for Prime Computer Inc. in Natick, Mass., 47-year-old Eaton was left to cope with a hefty mortgage, two children who he did not want to move to another school system, and competition from hundreds of qualified high-tech salespeople in the same predicament. And because of the highly specialized nature of his field, "it seems that unless you're experienced in a specific product, are five feet nine inches tall, and have blue eyes, no one wants you," he says with a grimace.

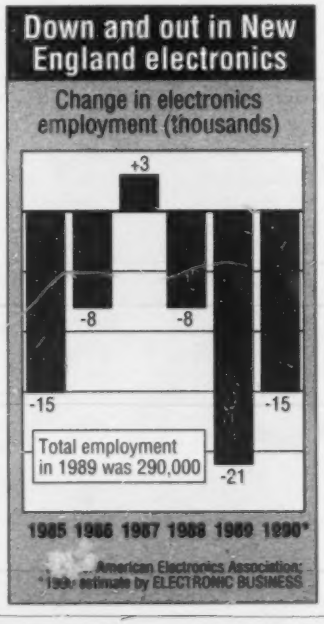
Eaton is just one of thousands of New Englanders who have been hit especially hard by the recession. The region not only is struggling with the downturn in the national economy, but also had been wrestling with sweeping changes long before the recession made the news last summer. For companies around "America's Technology Highway"—the Route 128 loop—the ride has become rougher than anyone had expected: By this past winter, nearly 1 of every 10 Bay State workers were unemployed, giving Massachusetts one of the nation's highest jobless rates.

New England has been a sort of lightening rod in the current downturn, explains economist Edward Moscovitch of Cape Ann Economics in Rockport, Mass. The main reason: a fundamental restructuring of the regional economy because of the virtual disappearance of defense and minicomputers as the most powerful drivers of economic growth.

"This recession has been devastating," says Barry Bograd, a human-resources consultant with Erdlen-Bograd Group Inc. in Wellesley, Mass. "Now engineers have adjusted their expectations. They are thinking, 'I'll take anything, I'll go anywhere.'"

Military matters

For giant defense contractors such as Raytheon, Lockheed Sanders, General Dynamics, and United Technologies, the problem isn't New England—it's Washington D.C. and the declining defense budget. While defense electronics will fare better than the rest of the defense procurement budget, it may never again see the easy-money, double-digit-growth days of the Reagan administration. Nor will the defense research, development, test, and evaluation budget—which drives the funding for many programs at the Massachusetts Institute of Technology in Cambridge and many companies in the state—rebound quickly from the Reagan heydays.



New England's dependence on military spending created jobs and growth throughout much of the 1980s. Between 1987 and 1989, Massachusetts received an average $1,405 per resident and Connecticut received $1,651 per resident in prime-contract awards—roughly three times the national average of $514 per capita, according to Yolanda K. Henderson, an economist with the Federal Reserve Bank of Boston. Last year, however, prime-contract awards to New England fell by 8%, and no end to the decline is in sight.

But New England defense contractors are fighting back. According to a survey of 355 defense companies in the region conducted last year by the Bank of Boston, more than three-quarters of the contractors have been adapting to the new environment by developing new lines of businesses, increasing marketing efforts to non-defense prospects, exploiting foreign markets, and exploring acquisitions or joint ventures to move into new businesses.

Profits will be elusive in this new, more competitive marketplace. While the Persian Gulf war meant extra business for Lockheed Sanders Inc. in Nashua, N.H. (the leading producer of aircraft radar jammers), the company is still staring down the barrel of fewer military contracts in the future. Lockheed Sanders's response has been to reduce the work force by 1,200 in 1990 and pare overhead across the board. "We began two years ago to position ourselves in order to compete in this tougher, more competitive environment," says company spokesman Marvin Braman. Adapting also meant refocusing product lines on those areas that Lockheed Sanders thinks will be more successful—avionics and anti-submarine warfare systems.

A few years ago, perhaps, many of

Maine

Number of employees*	5,000
Electronics jobs per 1,000 people	4
% change in employment ('89-'88)	0%

*Underestimated due to nondisclosures in telecom, navigation, and medical electronics industries

New Hampshire

Number of employees	35,000
Number of companies	229
Electronics jobs per 1,000 people	32
% change in employment ('89-'88)	-5.4%
% change in employment ('89-'84)	-12.5%

Vermont

Number of employees*	12,000
Electronics jobs per 1,000 people	22
% change in employment ('89-'88)	-7.7%
% change in employment ('89-'84)	+9.1%

*Underestimated due to nondisclosures in computer and instruments industries

Massachusetts

Number of employees	183,000
Number of companies	1,380
Electronics jobs per 1,000 people	31
% change in employment ('89-'88)	-6.6%
% change in employment ('89-'84)	-16.4%

Connecticut

Number of employees	46,000
Number of companies	575
Electronics jobs per 1,000 people	14
% change in employment ('89-'88)	-8.0%
% change in employment ('89-'84)	-13.2%

Rhode Island

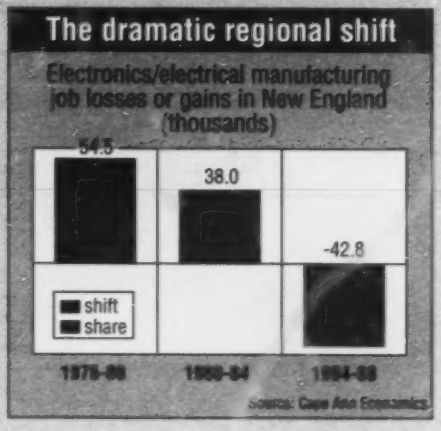
Number of employees	9,000
Number of companies*	88
Electronics jobs per 1,000 people	9
% change in employment ('89-'88)	-10.0%
% change in employment ('89-'84)	-18.2%

*Source: RI Dept. of Economic Development

How the miracle disappeared

There are two ways for a region to grow jobs. One is to have the right mix of growth industries and to grow those markets at the same rate as the rest of the nation. The other is to attract jobs and industries from other regions.

In the 1970s and early 1980s, New England did both well. The chart below shows the region gained nearly 55,000 jobs in the electronic and electrical equipment industries from 1975 to 1980, and 38,000 jobs from 1980 to 1984. Many of those jobs (31% in the '70s and 71% in the early '80s) were gained by shifting jobs from other regions in the U.S. But in the mid-'80s things changed. In four short years (from 1984 to 1988) New England lost almost 43,000 jobs, with 65% of those leaving to go to other regions. □



the unemployed defense engineers and salespeople could have made a successful transition to the minicomputer market, New England's largest commercial-electronics sector. Those companies sneaked past IBM in the late 1970s and early 1980s, and their success was one reason for the highly lauded "Massachusetts Miracle." But when West Coast PC and workstation companies executed their end run past the minicomputer in the mid-1980s, the miracle started to evaporate.

Today, most of the New England mini companies are known largely for their financial woes. Wang let over 3,000 people go in Massachusetts alone during the last two years. Data General left 600 Bay State citizens in the unemployment lines, Prime Computer almost 3,000, and Digital Equipment nearly 6,000 worldwide.

Despite these numbers, many New England business observers are surprisingly optimistic about the region's future. The severity of the downturn has been "overstated" by journalists who lack historical perspective, argues James M. Howell of The Howell Group in Boston. "They weren't here to see the regional recession in the '70s or the serious structural adjustments that took place here after World War II."

New England business leaders also take hope in their new governors, who are generally more pro-business than their predecessors. Massachusetts has been dealt an especially brutal blow by four solid years of spending deficits and three straight years of tax hikes. The result—not only in Massachusetts but also in neighboring states struggling with their own budget crises—has been a huge loss in business confidence.

When West Coast PC companies executed their end-run, the miracle evaporated

The changing of the guard has made some electronics executives more optimistic about their chances for survival and success. For the past two years, the Massachusetts High Technology Council's survey of Bay State companies showed that only 2% of high-tech executives expected improvement in the business climate; with pro-business governor William Weld now in office, the latest survey shows that 8% expect improvement.

Betting on pro-business state governments may be surer now than in the past. New Hampshire is trying to make doing business in the Granite State easier. "All the New Hampshire agencies that affect new business get together once a month now," says Bill Herman of the Department of Resources and Economic Development. "We've set up a network to try to get prospects through the system and solve problems more quickly."

Dan Daily, the new undersecretary of economic affairs for Massachusetts, is taking a pro-business message to the community too. "We're going out to the business community and saying that you are important because you control jobs," he says.

New England start-ups

"The factors that led to the minicomputer start-ups here in the late 1970s are still here," says economist Moscovitch. And New England's electronics start-ups are as vibrant and as active as ever. "We have incredible intellectual assets of well-trained workers and the infrastructure of lawyers, accountants, bankers, and suppliers who understand high-tech business," says Moscovitch.

Even small-business leaders who are struggling with the recession have an innate optimism about their home. Bob Forsberg, CEO of contract-manufacturing company Mutron Corp. of Brockton, Mass., and chairman of the New England Council of the American Electronics Association, laughs at the suggestion that the end of the Gulf war and the nationwide recession will mean the end to New England's economic troubles. "But New England is still a world-class place to live and a world-class place to own a business," says Forsberg.

First-rate universities such as MIT continue to generate a new breed of businesses that locate in New England. "I don't believe that a lot of things people measure—such as the tax rate, cost of housing, or cost of money—are big factors here," says Bernard Gordon, founder and CEO of Analogic Corp. in Peabody, Mass. "Look at Silicon Valley. It costs an awful lot to live there, but businesses are still starting there."

A story about Stardent Computer Inc. of Concord, Mass., illustrates the attractiveness and strengths of the region. Stardent was the result of a merger between a Bay State company and a Silicon Valley company. The president, John William Poduska, and a majority of the executives lived

A hopeful future: Four New England companies that shine

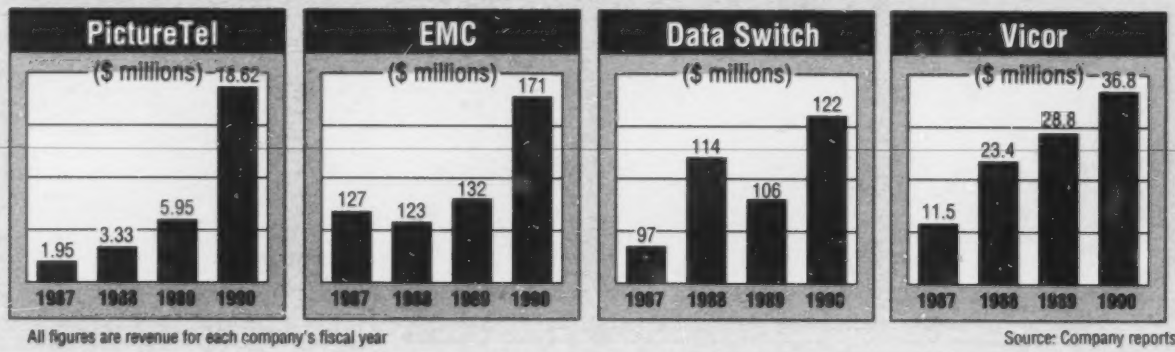
The future for electronics in New England isn't as bleak as the layoff notices in the local newspapers might suggest. In fact, many small start-up companies—particularly in communications, medical instruments, and technical software—did exceptionally well last year despite the recession.

PictureTel Corp. began as a result of HDTV research at MIT. Since its founding in 1984, this Peabody, Mass., company has become the world leader in videoconferencing. The company has doubled or tripled its revenue every year since 1987. Norman E. Gaut, president and CEO, expects the $18.6 billion company to have near 60% growth again in 1991.

EMC Corp., a manufacturer of computer storage products in Hopkinton, Mass., had been doubling revenue every year for eight years in a row until 1987. After the first loss in the company's history in 1988, EMC was forced to reexamine their entire production process. With the help of Conway Quality Inc.'s Continuous Improvement program and a new VP of quality assurance, the company grew revenue 30% to $171 million in 1990.

Data Switch Corp. has been a member of the Shelton, Conn., community since 1977. This switch maker grew revenue 15% to $122 million in 1990. Like EMC, a loss in 1989 forced the company to reevaluate its quality procedures. Data Switch is targeting exports as a major source of growth in the years ahead. Exports to Europe grew 50% last year, says CEO and president Robert Gilbertson. Next stop: Asia.

Vicor Corp. has made its proprietary power systems pay off big with 28% revenue growth last year. Princeton University physicist Patrizio Vinciarelli was talked into starting the business in Massachusetts because, says marketing VP Richard Beede, "that's where the skilled labor was." Boston's Route 128 was a natural choice, says Beede. The $37 million company does have one problem, however: not enough space in it's Andover, Mass., parking lot. □



All figures are revenue for each company's fiscal year

Source: Company reports

in Massachusetts. When it came time to consolidate overhead functions, they wanted to stay in New England.

Says company spokeswoman Roxanne Frisiello, "Along with a very strong belief that this area would be fine, the executives located the Stardent headquarters here because it was easy to find the people, the engineering talent, and the companies to get things done here." So in May 1990, while the region was slipping into its most severe recession since 1972, the company announced that it was locating the headquarters in New England.

Stratus Computer followed a similar decision-making process. Back in 1980, when he was trying to decide where to base his own computer startup, CEO Bill Foster also pitted Silicon Valley against Boston's Route 128. Foster had grown up, attended school, and had his first job with Hewlett-Packard Co. on the West Coast. Before starting Stratus, Foster was a vice president with Data General Corp. on the East Coast. By the time the decision of where to locate his company came up, his family was well settled in Massachusetts. But the location decision was primarily a business one. Back in 1980 there was simply a larger pool of systems design and software integration talent available in his adopted home state. The company landed in Marlborough, Mass.

As long as MIT, Harvard, and the rest of the regional colleges continue to attract bright minds to the region, New England will regain its old luster. Economist Howell points out that the long-term prospects are excellent, since the region has a "disproportionate" share of industries that are slated for strong growth: computers, peripherals, engineering and technical software, advanced materials, medical research and biomedical companies, and engineering, consulting, and financial services. "These industries are forecast to grow faster than others in the next decade," says Howell, "and New England has a large share of these industries."

So the corporate giants in defense electronics and minicomputers won't be the region's salvation, now or perhaps ever. Instead, the new start-ups will determine New England's future.

And whatever became of Ted Eaton? Twelve grueling months after leaving Prime, Eaton became vice president of sales and marketing for Workstation Solutions Inc., a small New Hampshire start-up. "I'm not with a traditional company any more," says Eaton, "but I got what I wanted—an opportunity to build and grow." As Eaton's new company and other small start-ups grow, New England will grow again too. □

Inventories: How low can they go?

Just-in-time management has taken some of the sting out of the recession. But some say a rebound could spark a new round of shortages

BY ELIZABETH B. BAATZ AND DAVE WEBB

Imagine that it's late summer and demand for your product is hot. Imagine also that because of an unexpectedly brisk economic recovery during the early summer months, your suppliers can't get their materials. Within a few months, the result is industrywide shortages that evoke memories of 1981 and 1984.

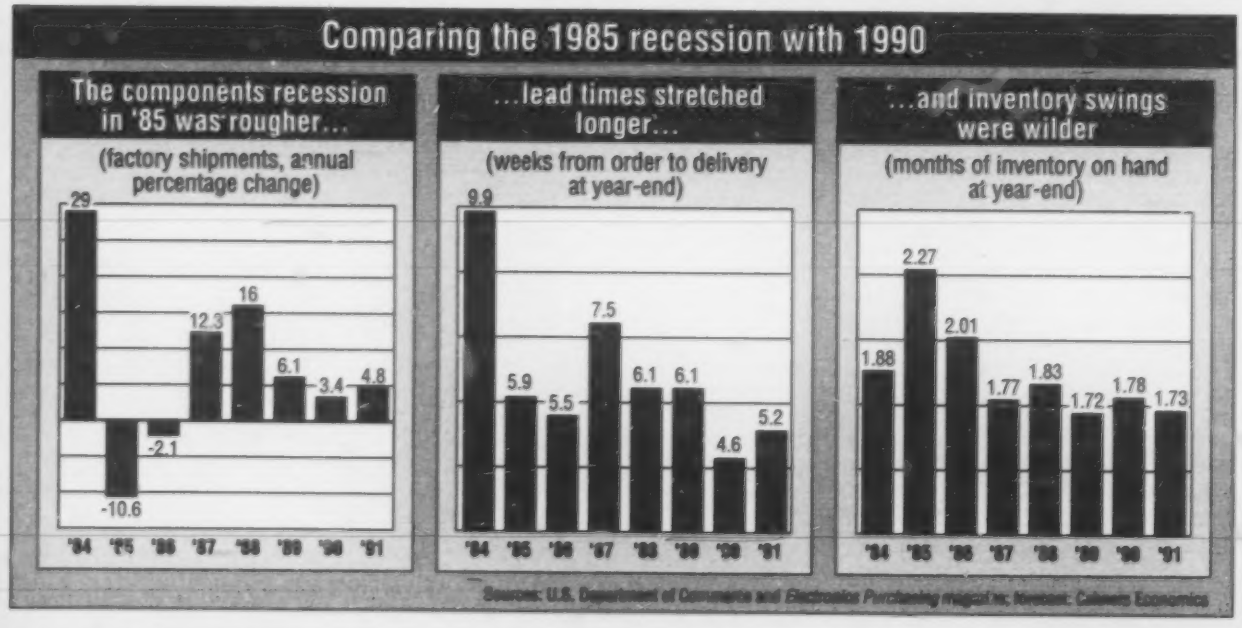
Many industry watchers think that such a scenario is not only possible but probable—if not during the coming economic recovery, then by the next one. The irony is, one of the reasons for the shortages just might be the resounding success of just-in-time inventory methods.

"As JIT becomes more prevalent, we will become dangerously prone to whiplash by the inventory cycle," warns Ralph Anavy of the Electronic Outlook Corp. in San Francisco. "Everyone will be scrounging around for product. If there is a disruption in the system, then I expect the system to break down."

Admittedly, many observers take issue with Anavy. After all, it was sophisticated inventory management during the most recent recession that prevented inventories from ballooning as they did during the recessions of the 1970s and 1980s. Because of those management skills, chip producers have cut their inventories from 39 days of supply on hand in early 1989 to 31 days by the first quarter of 1991, according to researchers at Dataquest in San Jose. Anavy adds that all component makers have cut stocks from 61 days in 1985 to 54 days in 1990.

The result has been a healthier bottom line for many companies. In 1980, for example, NCR Corp. carried over $1 billion in inventory, while revenue came in at $3.3 billion. By 1990 their inventory had fallen to $499 million, while revenue hit $6.6 billion.

But it's just this happy scenario that is giving some executives the jitters. Factory production can't turn around on a dime, particularly in capital-intensive industries such as semiconductors. And if the industry is fortunate enough to have a long, strong, and sustained recovery, it is unclear whether the inventory management practices that performed so well in the late 1980s will work in the unpredictable 1990s. "As long as overall market changes are gradual and orderly, JIT will function smashingly," says Anavy. But if market fluctuations are rapid and demand



change is sizable, he adds, "JIT will not perform in the United States up to expectations."

The reason, he says, is that successful JIT policies hinge largely on a tradition of supplier-user cooperation—common practice in Japan, but relatively rare in the U.S., where business relationships tend to be more adversarial.

The 25% premium

The push to trim inventories is not new, of course. Competition from Japan, shorter product life cycles, and reduced margins have focused management's attention on return on assets. Besides the cost of capital, hidden inventory costs include warehousing, maintenance, insurance, taxes, erosion of inventory, rework, and scrap.

As a result of this increased attention to costs, unwanted inventories have been largely nonexistent lately. Many component companies seemed to have anticipated the recession and adjusted their inventories as far back as 1989, says George Miller, president of a Chatsworth, Calif., consulting firm. The response by semiconductor maker Cirrus Logic Inc. typified the industry's inventory policy, especially during the Gulf crisis. "Because of uncertainty in the Gulf, we focused on our manufacturing forecast and brought inventories in," even as revenue grew, says Cirrus Logic's marketing vice president George Alexi.

The changing inventory policies of American industry has carried some unexpected benefits. In electronics, better inventory management changed the very nature of the latest industry slump. Compared with the wild gyrations in inventories in past recessions, the latest experience has been mild indeed.

More predictable inventory swings have benefited one industry segment in particular—electronics distributors—a group that has traditionally been most dramatically impacted by such fluctuations. But while distributors suffered slowdowns or minor sales losses in the past year, the pain has been nothing like the trauma of earlier sales contractions. "With so many customers having such small inventories, they could stop buying for four weeks instead of four months [to correct any inventory overhangs]," says Steven Kaufman, president and CEO of Arrow Electronics Inc. in Melville, N.Y. "So the recession impact has been much milder at the supplier and distributor level. My company hasn't seen it at all this time compared with the last recession."

Lee D. Henning, vice president for the manufacturing support division of Data General Corp. in Southborough, Mass., tells a similar story from the OEM's perspective. "We came off the 1983 to 1984 period out of everything," he says. "We were selling product well in advance of the supply line. When this downturn came, we were already into cost controls, and we were much more selective about suppliers. So we did not have to modify much."

There's another industrywide benefit from better inventory management: A rebound in the economy will show up quicker in higher fac-

A climate of JIT excellence

Despite the doom and gloom about JIT from industry analysts and consultants, many U.S. companies have made tremendous progress in the past decade.

A good example is IBM's Rochester, Minn., plant, where inventory turns have increased 60% from 1985 to 1990, according to plant manager Andy Papamarcos. One pressure that helped: an increase in manufacturing cycle times. "Back in '85, we measured cycle times in months and weeks. Now they are measured in hours," says Papamarcos.

NCR's Tom Kane: "If you don't learn how to manage low inventories one step at a time, you will fail"

At the Huntsville electronics division of Chrysler's Acustar Inc., meanwhile, the normal delivery window is four to eight hours, which has forced many suppliers to utilize third-party warehouses near the Atlanta plant.

"We averaged 50 to 100 shortages a week in 1985, largely because we had so much inventory that even if the material was [at the plant] we couldn't find it," says Jerry McCarty, Acustar's production control manager. "Today we might have an average of five shortages a week."

NCR Corp.'s statistics comparing 1980 and 1990 are impressive as well. How did they do it? They did not change their organizational structure, explains manufacturing vice president Tom Kane. "We adopted JIT by having each plant appoint a JIT champion. You cannot dictate low inventories. It's a journey—if you don't learn how to manage low inventories one step at a time, you will fail." □

NCR's inventories then and now

1980	1990
$1 billion in inventories on $3.3 billion in revenue	$499 million in inventories on $6.3 billion in revenue
3 inventory turns each year	12.7 inventory turns each year
400 suppliers per plant	150 suppliers, per plant with 25 providing 80% of the plant's purchases
75 days of supply on hand	17 days of supply on hand
100 items on shortage list	1 to 2 items on shortage list

Source: NCR Corp.

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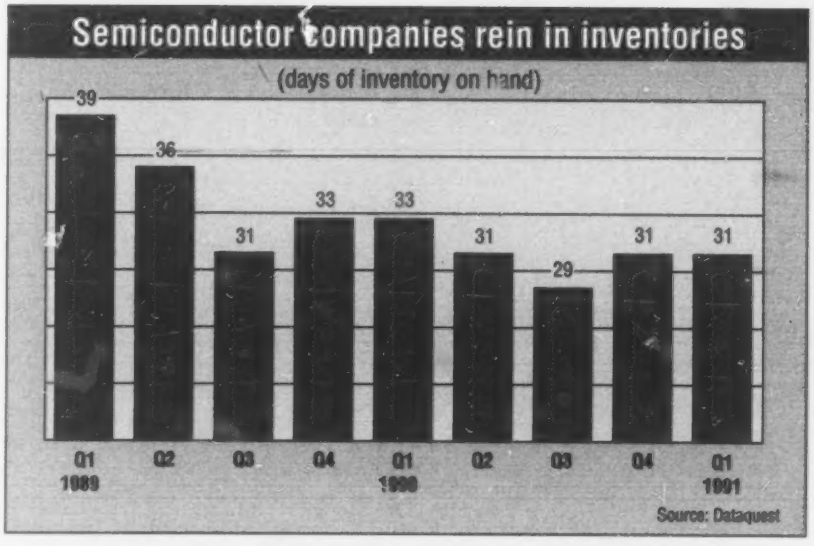

tory-production rates than in previous recoveries. In the past, inventories accumulated during recessions; when the recession ended, producers satisfied customer demand—not by stepping up production, but by using up their excess stocks. Now, with little unwanted stock in the warehouse, producers will have to ramp up their plants faster when demand recovers.

The "illusion" of JIT

So what accounts for the warnings being issued by some industry observers? For one, the large number of inventory levels in the supply chain—from component suppliers to equipment manufacturers to OEMs—leaves the system vulnerable. A weak link in the chain can throw the entire system out of whack. If every link in the supply chain has drastically reduced inventories, then the risk of shortages rises.

As a result, at least one economist thinks that widespread shortages could hit the electronics industry even sooner than Anavy predicts. "It could happen this year because most people aren't yet optimistic about the current outlook," says Ed Henderson, president of Henderson Ventures in Los Altos, Calif., who predicts double-digit growth in semiconductor sales in 1991. If a significant number of companies underestimates demand as the economy emerges from the recession, he says, then there could indeed be trouble.

What makes Henderson, Anavy, and others so nervous is the suspicion that few companies are actually using JIT. "When companies say they've gone to JIT, don't believe it," says professor James Reeds, a regional education director for the American Production and Inventory Control Society Inc. in Falls Church, Va. While agreeing that manufacturing inventories are being handled better, Reeds remains skeptical about what he calls "the illusion of JIT."

Like total quality management, he says, true JIT is a journey. "It is excruciatingly slow," says Reeds. "The Japanese have 40 years of trial and error [in JIT], while we in the United States are just ending our first decade." He suggests that it could be another decade before true JIT is widely adopted in the United States.

In many cases, says Reeds, equipment makers simply hide their costs by forcing suppliers to hold their parts inventory. While that policy cuts the equipment makers' inventories, suppliers merely pass along their higher inventory costs to the customer. And if buyer-supplier partnerships are weak, or if JIT is otherwise poorly implemented, then Anavy's scenario may not be so unrealistic.

Other factors could contribute to widespread shortages in the electronics industry under the rubric of JIT. Salespeople can forecast incorrectly.

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Suppliers may have the incorrect mix for capacity. Procurement personnel can inadvertently build up inventory. "Relative to four or five years ago, things are markedly improved," says senior analyst Mark Giudici with Dataquest Inc. in San Jose. "People are talking to each other, but not as much as the textbooks want. There is still room for improvement in forecasting and communication."

Many large companies claim to be unworried by the prospect of sudden shortages. "It depends on who you are in the supply chain," says Russel Craig, a vice president with Arthur D. Little in Cambridge, Mass. "Big companies have the communications systems and size to demand attention, but smaller companies that don't have the purchasing clout may have a problem."

In Japan, JIT policies hinge largely on a tradition of supplier-user cooperation

NCR's Kane is optimistic about his company's abilities to manage supplies in an upturn, since NCR focuses on customer response, not on inventories. It's a cultural change that has been ongoing at NCR a number of years before the 1984 to 1985 inventory scare, says Kane. Total quality management and strategic alliances with suppliers were begun in the '80s. Now NCR is looking for continual improvement in forecasting and is investigating ways to add incremental capacity quickly.

In fact, while large companies are generally confident of their supplier relationships and their ability to avoid shortages, each is continuing to improve even more. Prior to total quality management at NCR, according to Kane, "We were in a continual expedite mode. . . When we had a lot of inventory back in 1980, I could go to any plant and see a hundred parts on the shortage list. Now I go to a plant and see just one or two parts on the shortage list." Those improvements, he says, mean that NCR will be able to respond to customers as well in an upturn as in a downturn. □

Europe to liberalize satellite services market by 1992

But U.S. companies worry that they will have to fight their way into what may yet become a politically heated arena

BY LINDA BERNIER

U.S. satellite equipment manufacturers are scurrying all over Europe to consolidate their markets and cash in on the impending liberalization of Europe's communications satellite market. Their goal: to nail down an even bigger piece of the action in the European Community's $331 million satellite services market.

As that market opens over the next three years, however, some Europeans balk at the prospect of being overrun by U.S. competitors. Buoyed by military and space R&D contracts and vertically integrated activities, U.S. companies have been far more aggressive than their European or even Japanese counterparts: Until recently, U.S. manufacturers held 75% of what is now a $4.6 billion "second-generation" world satellite communications equipment market, while European manufacturers (led by France's Alcatel N.V.) held a meager 20%.

The European Commission issued its Green Paper on Satellite Communications last November and has since consulted with industry, users, and service providers in order to prepare the new laws. A framework directive is scheduled to be issued by the end of this year.

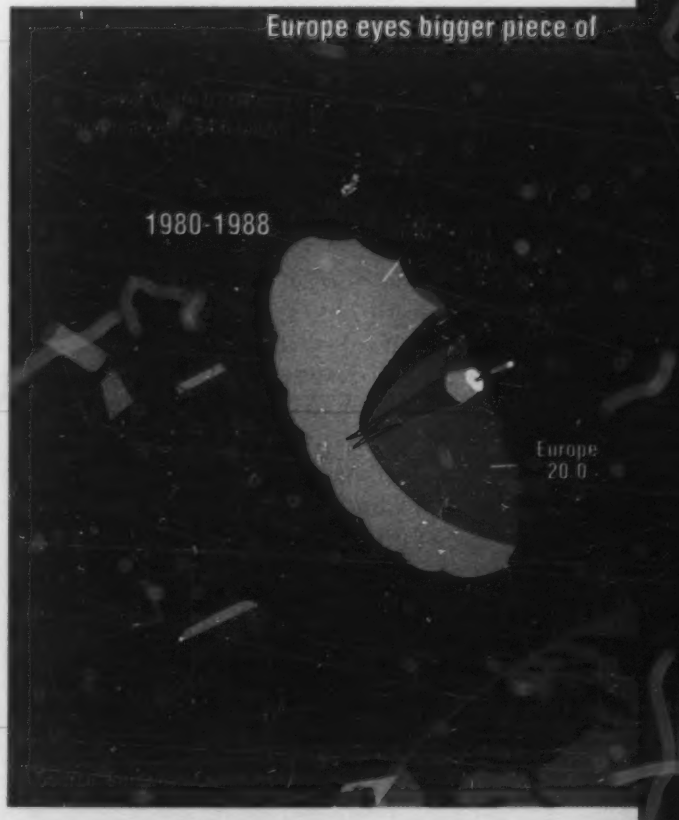
The Commission's proposals are designed to open up the earth segment (including receive-only and transmit-receive terminals), provide unrestricted access to the space-segment capacity, and allow full commercial freedom to space-segment providers—including direct marketing of satellite capacity to service providers. These markets now fall under the highly restrictive control of most European national operators (the "PTTs"). Along with European equipment makers, the PTTs are fighting hard to protect their turf.

But U.S. manufacturers are just as determined to push deeper into the market. Over the next 18 months, for example, industry leader Hughes Network Systems Inc. hopes for an eight-fold increase in its European sales of very small aperture terminals or VSATs—the small, two-way satellite units suited for business use. AT&T Tridom is courting PTTs all over Europe and identifying potential customer network clients. "We're up to our gunwales trying to win some of the requests for proposals for VSAT equipment," says Jon Collins, AT&T Tridom's European marketing director. Hughes may be market leader, he says, but "we're certainly not going to lie dead."

The Commission predicts that the worldwide satellite revenues will rise to only 1.5% to 2.5% of total telecommunications services by the year 2000, versus the current 0.4%. But the Commission also figures that by opening up the highly fragmented European market, economies of scale will slash the cost of a commercial satellite by up to 40%. Policy makers also hope that liberalization will boost new satellite business services—particularly in the financial, manufacturing, and retail sectors, which today account for only 10% of all European satellite services.

More U.S. domination?

But many Europeans see most of the benefits of liberalization accruing to non-European companies. "If you open the market tomorrow, it will be completely dominated by U.S. suppliers and operators," says Jacques Blanche, a director at Alcatel and chairman of the regulatory affairs



group of the European Telecommunications and Professional Electronics Industry. Blanche wants the EC and other government institutions to provide increased R&D funding and programs to European satellite communications manufacturers so they can compete more effectively against U.S. companies. "It's too late for the first-generation products, but it's not too late for the second-generation products," he says.

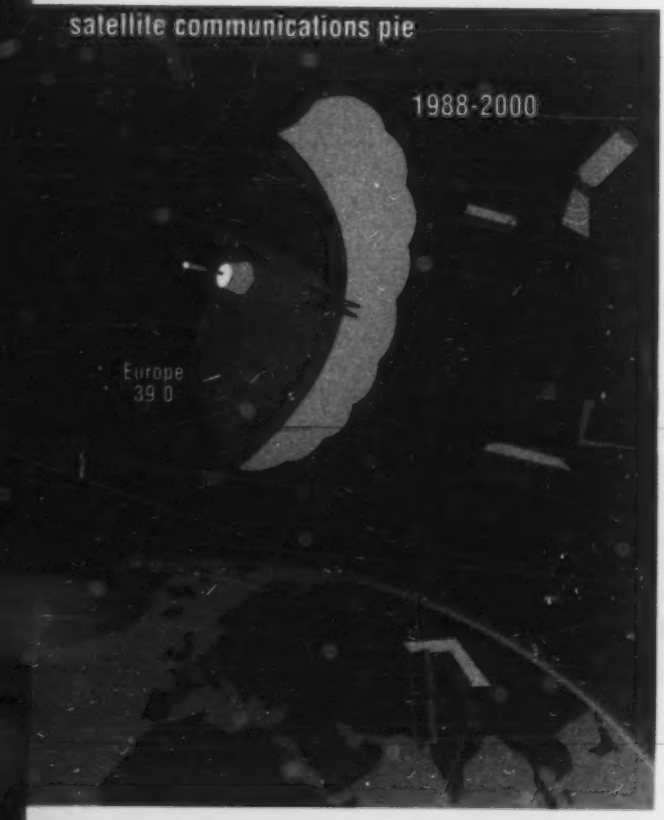
Some U.S. executives, fearful of ruffling European feathers, are keeping a very low profile in the debate. "We don't want to get involved in politics," says one.

Others are not so shy. Andrew Werth, president of Hughes Network Systems, Europe's major VSAT supplier, doesn't think taking $60 million a year worth of Europe's available VSAT business justifies protectionism. "It's not our ambition to steal all of [Europe's] business," he says. "We have made major investments in our products and we want to sell them." He thinks that if liberalization takes off, the European VSAT market could grow from about 10,000 today to about 40,000 over the next five years.

To better position itself, HNS has forged distribution and maintenance alliances with Germany's Dornier GmbH and Selenia-Spazio SpA of Italy. AT&T Tridom expanded last year's distribution agreement with France's Matra Espace to allow it to manufacture, assemble, and test its technology in Europe, bringing local content up to 30% or 40%. AT&T Tridom has also established a distribution agreement with the German telecommunications equipment maker, Fuba A.G.

A gradual opening

European companies, meanwhile, are not standing idly by. Both British Aerospace plc and Daimler Benz A.G. are involved in satellite systems and are increasing their vertical integration. British Aerospace established British Aerospace Communications Ltd. as a satellite service operator two years ago, for example, and the parent company has since set up ventures in TV broadcasting and business TV. Daimler Benz Interservices A.G. also was created two years ago to provide satellite communications services and act as an operator as Germany deregulates its satellite services market.



Still, liberalization won't be easy. European PTTs—particularly in France, Spain, and Italy—are expected to fight attempts to quickly open up Eutelsat (the European satellite organization) to direct access by users. Access is now controlled by the 28-member PTTs who finance Eutelsat.

Luc Perrouin, responsible for European affairs in France Telecom, says the French operator doesn't oppose gradually opening up Eutelsat sometime in the future. But, he says, it's unfair to allow users who haven't invested in Eutelsat to reap its benefits. "We want to preserve this costly investment," he says, noting that France Telecom has invested more than $396 million in satellites. Providing direct access right now also might jeopardize Eutelsat's fragile existence by prompting some members to leave for less costly suppliers, he adds. Eutelsat turned profitable only last year, after six years of operation.

Eutelsat itself also favors a gradual approach to direct access. Eutelsat now advocates providing user access through its members, meaning members could authorize users to deal directly with Eutelsat or set up offices separate from their own commercial activities, suggests Birgitta Naeslund, executive assistant to Eutelsat director-general Jean Grenier.

U.S. companies also worry that European countries might set discriminatory equipment standards, which could place financial burdens on competitors. The planned directive thus will call for mutual recognition of type approval for satellite communications terminal equipment, licenses for satellite terminal networks, strengthened frequency coordination, definition of open network provisions concerning the connection of satellite terminal networks, and harmonization of identified future transmission techniques for satellite broadcasting to the general public.

Today, national restrictions are a regulatory nightmare. British satellite service provider SIS Link Ltd. can uplink directly to the United States from Germany, for example, but not from Britain. And in France SIS Link must buy terminal equipment from France Telecom instead of providing it to the customer directly, explains Nicholas Thorley, the company's managing director.

But there are signs that liberalization of the telecommunications market is already underway, led by both Britain and Germany. Other governments generally support the Commission's proposals. HNS's Werth is optimistic about the future and looking forward to a plethora of transborder VSAT networks. After all, he says, "three or four years ago, who would have guessed that the [German PTT] would be leading the charge on liberalization?" □

Wireless LANs broadcast their benefits over cable

Questions remain about cost, performance, and interference, but new market entrants NCR and Motorola help legitimize the field

BY DWIGHT B. DAVIS

More than a decade ago, Xerox Corp. researchers branded a promising data communications development "Ethernet." As a product backed by Xerox, Digital Equipment Corp., and Intel Corp., Ethernet was destined to set the pace for the emerging marketplace of local-area networking.

But Ethernet didn't really deliver on the ethereal promise of its name, nor did any competing LAN implementations. All the LANs were decidedly earthbound, dependent upon thousands of feet of snaking copper or fiber cable to deliver their messages.

The cable did the job, but installing it in some offices proved a nightmare. Then, once the cable was in place, the LAN configuration was essentially hard-wired; moving workstations or expanding the network could require more cabling expense and further office disruption.

Wireless networks, by contrast, offer the promise of easy installation and simple network reconfiguration. Most can operate independently or can piggyback on existing cable-based LANs. Wireless technologies do have their liabilities—questions of cost, performance, and signal interference have slowed market acceptance. But the recent arrival of products from Motorola and NCR are seen by many observers as a sign that the message of wireless benefits will finally get through.

Cutting cable's grip

Cable's monopoly began to unravel in the late 1980s when pioneering companies such as Photonics Corp. (Campbell, Calif.), O'Neill Communications Inc. (Princeton, N.J.), and Telesystems SLW Inc. (Don Mills, Ontario) brought wireless datacom products to market. The products, which used either infrared light or UHF radio waves to transmit information, found some ready buyers. But the wireless LANs ranged in speed from 19.2 kilobits per second to about 250 Kbps—much slower than established LANs such as Ethernet (10 megabits per second) and Token Ring (4 Mbps or 16 Mbps). In addition, the products' vendors weren't exactly household names.

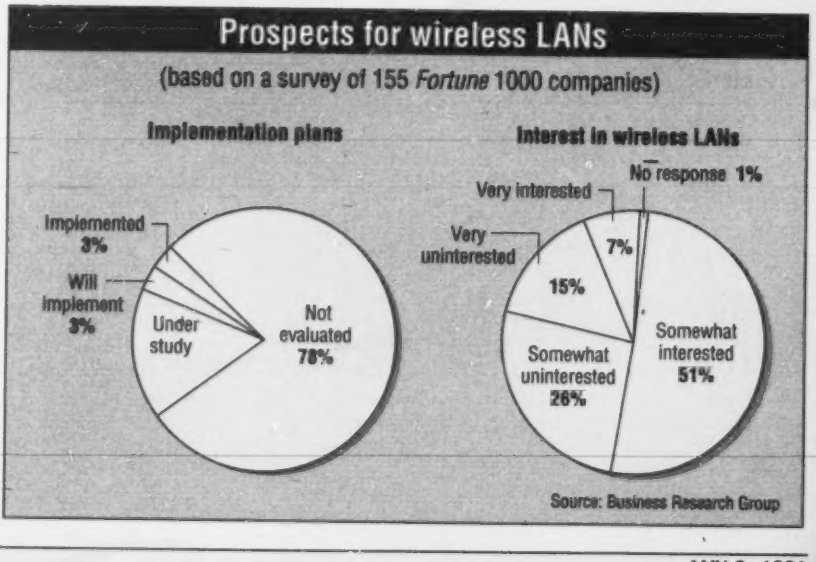
"We spent about a year developing a wireless product, but then we got out of the business," says Michael Plotnick, president of T/BD Associates in Princeton, N.J., now a consulting firm. "We found that the time wasn't yet right for a small start-up company in this market."

The scenario began to change last September when NCR in Dayton, Ohio, introduced its 2-Mbps WaveLAN product. Shortly thereafter, Motorola in Arlington Heights, Ill. demonstrated its wireless in-building network technology. The first product based on this technology—the 10-Mbps Ethernet-compliant Altair network—debuted in February.

A third new arrival, BICC Communications—an operating company within BICC Technologies Inc. of Westborough, Mass.—has unveiled a wireless LAN that supports 4-Mbps and 16-Mbps Token-Ring operation. BICC's InfraLAN product is based on technology the company acquired last year from a research group called UnTied Telecom.

These companies bring name-recognition and financial resources to the wireless LAN business. Each employs a distinct wireless technology (see "High-speed wireless LANs"), but all have proven that wireless products can match the speeds of the most popular cable-based LANs.

What these and the other wireless LAN vendors have yet to prove is the market potential of their products. Most believe the prospects are



bright. "We made our 1991 sales goals in the first six weeks after the InfraLAN introduction," says Michael J. Noonan, executive vice president at BICC Communications. He predicts that within three to five years, 25% of Ethernet and Token-Ring sales will be wireless products.

Others aren't so sure. In a survey of 155 *Fortune* 1000 information system executives, the Business Research Group in Newton, Mass., found that 78% had not yet evaluated wireless LANs as a networking option (see "Prospects for wireless LANs"). The market research firm also noted various drawbacks associated with wireless technologies and predicted that the market for wireless LANs would not exceed 7% of the total LAN market. "Although wireless LANs have many practical advantages, they will prove to be only niche products," stated BRG's survey report. "The vision of a wireless office has as much chance as a paperless office."

High-speed wireless LANs

Company/Product: Motorola Altair
Technology: 18-GHz radio, 25 milliwatts power
Speed: 10 Mbps (Ethernet compliant)
Product benefits: Closed office operation; licensed spectrum free from external interference
Product liabilities: Licensing required; uses external radio units; unanticipated radio propagation could interfere with nearby Altair microcells
Costs: Control module (one per microcell) — $3,995; User module (supports up to six users) — $3,495

Company/Product: NCR WaveLAN
Technology: Spread spectrum in 902- to 928-MHz band, under 1 watt power
Speed: 2 Mbps*
Product benefits: Closed office operation; configured as integral PC card; no licensing required
Product liabilities: Must share band with other unlicensed devices, raising interference concerns; not Ethernet or Token-Ring compliant (but is compatible)
Costs: Network interface card (one per user) — $1,390

Company/Product: BICC InfraLAN
Technology: Point-to-point infrared LEDs
Speed: 4 or 16 Mbps (Token-Ring compliant)
Product benefits: Immune to electromagnetic interference; signals don't propagate through walls; familiar to users of remote control devices; no licensing required
Product liabilities: Requires wiring or wall apertures to penetrate closed offices; uses external infrared units.
Costs: Base unit (supports up to six users) — $2,995

*NCR claims WaveLAN's 2-Mbps maximum data rate is roughly equivalent to the achievable maximum rates of Ethernet and Token-Ring LANs (rather than their theoretical maximums). □

Wireless barriers

One of the barriers wireless LANs must overcome, according to BRG, is their high price relative to wire-based networks. But the wireless vendors believe their products already compare favorably to traditional LANs. Cost comparisons, the vendors argue, must consider the networks' lifetime costs, not just the initial purchase prices.

The distinction is important, since the key selling point for wireless products is the flexibility they permit in making LAN workstation adds, drops, and moves. Making such configuration changes with wire-based LANs can involve expensive, if not impossible, rewiring.

The experience of Travelers Insurance in Hartford, Conn., a beta site for BICC's InfraLAN, bears out the potential cost benefits of wireless installations. Travelers standardized on Token-Ring networking and went with the BICC product because it provided a seamless link to its existing cable-based LANs, says Nick Blazensky, a Travelers director and manager of site design.

Putting LAN cabling in new office space at Travelers cost only $300 to $350 per station, but the cost ran from $500 to $1,100 per node if the wiring had to go into office space that was already occupied. In the latter cases, drilling holes, pulling cable, and testing had to occur during off hours, and labor costs skyrocketed. The latter case was typical at Travelers', whose targeted LAN installations were at its existing field offices.

BICC's InfraLAN units cost $2,995 each, but each can support up to six users. At $500 per user, InfraLAN's best-case, up-front costs compare favorably to the wired LAN solutions. In addition, the products can be installed by the users themselves without major office disruptions—an important benefit as LAN configurations evolve. "We move about 30% of our installed base each year," says Blazensky, "so ease of installation is a big factor."

Performance specs

With the introduction of the NCR, Motorola, and BICC products, the skepticism about the speed potential of wireless technologies has started to evaporate. Indeed, Motorola—which uses low-power, 18-gigahertz (GHz) radio as its transmission medium—can scale its technology to support 80-Mbps to 100-Mbps speeds, says Mil Ovan, senior marketing manager for Motorola's Altair network.

BICC's point-to-point infrared technology could also support such rates, claims Noonan. Even NCR's wireless technology—based on so-called "spread spectrum" radio transmissions in the 902-megahertz to 928-MHz bandwidth—has much higher speed potential, says Daryl R. Maddox, senior product manager within NCR's Financial Systems Division. "Many say spread spectrum can't go much faster, but we use only half of the available bandwidth. In the upper bands, we're looking at running at up to 40 Mbps."

With wireless LANs, though, speed is not the only performance issue. Depending upon the transmission technology employed, the networks can be susceptible to interference or to outright blocking of the signals.

Infrared transmissions are immune to interference from outside electromagnetic sources but can be physically blocked by walls, ceilings, floors, and people. As such, infrared is commonly perceived to be most suitable for open office environments where transceivers can transmit directly to one another or can bounce transmissions off a common ceiling

or wall. For linking closed office stations to the networks, users can run a wire through the wall to a transceiver mounted in the open office space, or they can cut apertures in the walls through which the beams are able to pass.

Radio transmissions, unlike infrared, can pass through office walls, and systems employing either spread spectrum or higher-frequency radio waves can therefore serve easily in closed as well as open office spaces. "But going through walls can be an advantage or a disadvantage," says Gary Hughes, chief executive officer of Photonics, an infrared systems supplier. Adjacent radio networks can potentially interfere with each other, he notes.

Motorola avoids such interference, says Ovan, by operating in a band that requires FCC licensing. With two licensed frequencies for each site, Motorola is able to set up discrete "microcells," with adjacent cells using different transmission frequencies. But radio waves can travel unanticipated distances depending upon the number and the composition of the barriers through which they pass, making it difficult to predict the exact area covered by each microcell, skeptics warn.

Motorola's licensed approach does have the advantage of ensuring that its Altair networks are the only systems transmitting at their assigned frequencies. Spread spectrum, by contrast, shares unlicensed Industrial, Scientific, Medical (ISM) radio bands that can be populated by other emitting equipment.

New technologies help wireless LANs compete against cable-based systems

However, concerns about ISM interference are overrated, according to NCR's Maddox, who claims the bands "are among the quietest of all bands available." Exterior noise can occur, he admits, especially from devices such as radio location systems, which can interfere with spread spectrum networks blocks away. But WaveLAN is designed to overcome such interference and has the advantage of not requiring an FCC license, he says.

Technical debates aside, the wireless LANs must overcome one other obstacle in their quest for market share: users' health concerns. Although the networks all operate at powers and frequencies thought to be harmless to humans, "there seems to be a general, low-level paranoia about these systems," says Kevin O'Neil, vice president of network research and consulting at BRG.

In this regard, infrared technology—familiar to everyone who owns a remote control TV unit—may have a marketing advantage. "There's no argument that infrared is as safe as a church," says Hughes at Photonics. □

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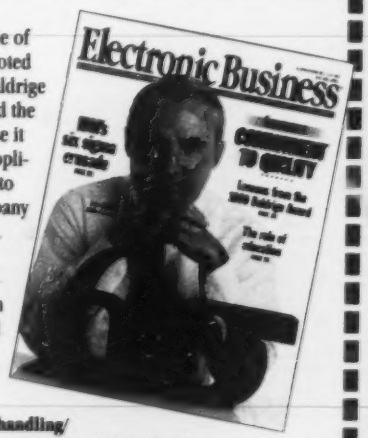

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The accelerating market for auto sensor devices

Sales soar, but bringing advanced technology to the auto industry still takes time, with no guarantee of quick payoffs to suppliers

BY JOHN PARKER AND XIONG XIAOGE

Climb behind the wheel of a $60,000 Corvette ZR-1 and scan the electronic dashboard, which happens to be one of its sexiest selling points. Sensors throughout the vehicle will tell you, among other things, the outside air temperature and the car's current gas mileage.

Even a modest sedan boasts sensors that monitor engine performance. Emerging sensor requirements—created by such features as air bags and antilock braking systems, or ABS—have revved up the staid development cycle of auto electronics technology. Take an imaginary drive into the technological future, and you may find sensors that first warn you of an oncoming tractor-trailer then automatically apply the brakes and steer you out of harm's way.

All this makes a case for cracking the auto sensor market, but experts urge caution. Small high-tech companies now supplying sensors for other applications need to know that the automotive market is different: High volume—in the hundreds of thousands of units—and low cost are the watchwords, and a systems-oriented partner with deep pockets is a valuable ally in approaching major auto makers.

Although automotive sensors are still relatively new on the scene, the growth of the industry is remarkable and tracks the general "digitization" of the automobile. The all-brawn-and-no-brains car of the early 1970s had less than $25 worth of sensors, microprocessors, and diodes on board. By 1995 the average Ford will carry $900 worth of non-entertainment electronic components, according to Michael McGrath, managing director of Pittiglio, Rabin, Todd & McGrath (PRTM), a Weston, Mass., consulting firm for electronics manufacturers. Sensors will account for about 20% of that.

Much of the demand comes from government requirements for improved emissions control, fuel economy, and crash protection. California will soon require on-board diagnostic systems, for example, and the rest of the nation is expected to follow.

As a result, the North American market for automotive sensors should surge from 85.1 million units for the 1990 model year to 173.3 million units for 1996-model cars, according to a recent forecast by Market Intelligence Research Co., a Mountain View, Calif.-based market research firm. Sensor revenue is forecast to jump from $803.6 million in the 1990 auto model year to $1.8

North America's accelerating market for auto sensors

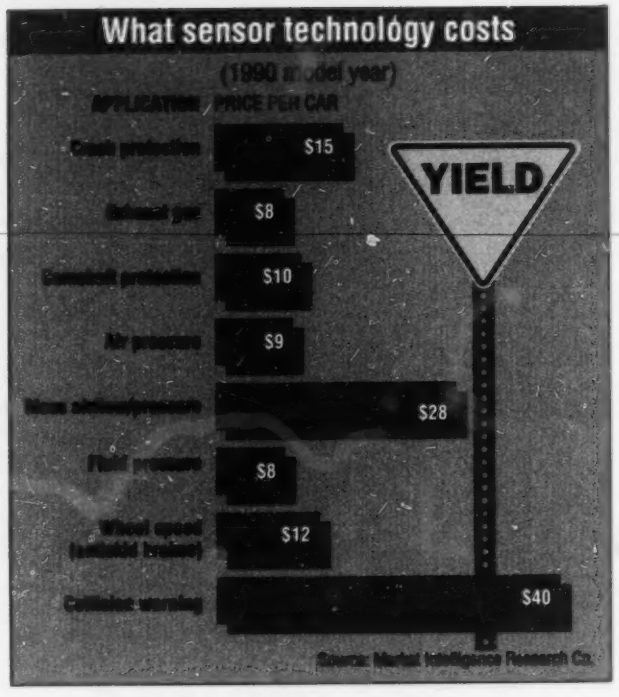
($ million sales)

Source: Market Intelligence Research Co.

billion in 1996, posting a compounded annual growth rate of 14.4%.

Choosing partners

Areas of anticipated growth in the 1990s include motion and position sensors, pressure sensors, and accelerometers, particularly those used in air-bag systems and ABS. To exploit those high-growth areas, sensor manufacturers may have to choose partners among automobile and auto electronics companies. "It's important for the sensor makers to seek joint activities with the auto makers in design, R&D, customer-funded research, development, or joint ventures," says McGrath. Moreover, suppliers can expect a three-to-five-year wait before finally getting the go-ahead to start mass-producing a new chip-based sensor, McGrath explains, "so a partnership with the auto maker will lessen some pain and help secure the order."



An example of such a partnership is last year's acquisition of NovaSensor—a Fremont, Calif., sensor manufacturer with about $8 million in sales—by $3.5 billion Lucas Industries plc of Birmingham, England. An innovator in silicon-based pressure and acceleration sensors, five-year-old NovaSensor primarily supplied the medical and industrial markets. The company had developed sensors-on-a-chip to measure pressure, acceleration, force, and flow using its own bonding process and was poised to attack the automotive market.

But like other small manufacturers, NovaSensor faced major hurdles. "It's tough to go to a big Detroit auto maker with a chip," remarks NovaSensor marketing manager Gary Winzeler. "They don't buy a wheel, they buy a wheel *assembly*," he says. "And when they buy sensors, they buy *systems*." Like other manufacturers assaulting the automotive market, NovaSensor also had to face the realities of producing components in huge volumes at low cost.

Although the trend toward greater on-board computer intelligence argues for the use of components with what Winzeler calls "smart functions," analysts say major auto makers are not necessarily eager to push new products. Having invested heavily themselves in older and non-transferable technology, say analysts, they may want to slow the market for newer products until they are ready to produce those products themselves.

In NovaSensor's case, the answer was systems house Lucas, which was shopping for a leader in auto sensor technology, especially for ABS and air-bag systems, according to San Francisco marketing consultant Roger Grace. Lucas picked up all outstanding shares of NovaSensor for an undisclosed sum, says Grace, and provided the Silicon Valley company with immediate access to systems-engineering capability and more clout with auto makers. At the same time, Lucas allowed NovaSensor to enter R&D alliances with other automotive electronics suppliers.

The deal with Lucas prompted NovaSensor executive vice president Janusz Bryzek to proclaim that "we expect to become a world-leading supplier of automotive pressure and acceleration sensors within three years." At present, though, it's too soon to talk market share. Sales of auto sensors will account for only a portion of the company's expected $14 million revenue in 1991. "They have a number of R&D contracts," says consultant Grace. "But in this business it takes years" to establish a strong market presence.

In fact, market-share figures overall are hard to come by in the field of auto sensors. The newer technologies haven't yet produced measurable sales, and analysts agree that many companies working in those technologies are keeping quiet to avoid alerting competitors. Some major auto makers, including Ford, manufacture sensor devices in-house. The role of auto makers' captive suppliers (such as General Motors supplier Delco Electronics Corp.) further cloud the picture.

But it's clear that the auto sensor market has attracted electronics heavy-hitters. In Phoenix, for example, Motorola Inc.'s automotive products division has shipped more than 10 million sensor units for auto applications over the past three years, supplying both to auto makers and auto electronics suppliers. The company manufactures manifold air-pressure (MAP) sensors and is investing millions in research and development of accelerometers, according to automotive strategic marketing manager Bill Van Tine.

Technology shift

While industry experts agree the auto sensor market is due for strong growth, the pace of technological change may be slower. "The industry is ready for something new," says Paul Hansen, editor and publisher of *The Hansen Report on Automotive Electronics*, published in Goffstown, N.H. "The problem is that to bring new technology to the market takes years and years" because of price and supply concerns. "In the automotive industry," says Hansen, "proven technology is where it's at."

Present sensor systems do tend to rely on tried-and-true electromechanical technology. However, there's growing attention to the applicability and potential of solid-state

devices. In a typical air-bag system, as many as five accelerometers are installed at the front of the vehicle as crash sensors, with an arming sensor in the driver's compartment to prevent the bag from inflating accidentally. In a collision, the effects of rapid deceleration elicit an electrical signal from the crash sensors. If the electrical current exceeds a predetermined level, it ignites the propellant that inflates the bag.

Then there is the ABS system, relying on sensors that track the speed of each wheel. Add to the list the fluid-level sensors that monitor engine oil and the airflow and engine-speed sensors that track engine performance. As engineers tie all these sensors together, say experts, precise, instant, and direct measurement becomes more and more important.

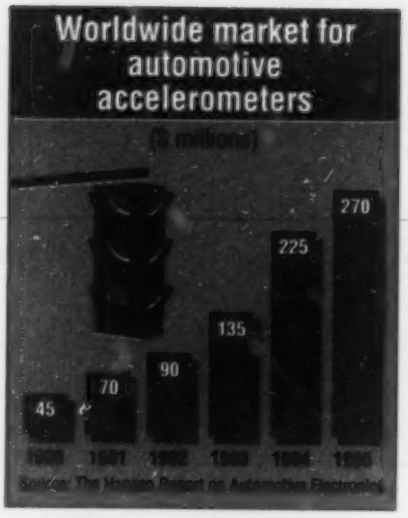
A case in point is the development of mass airflow sensors. The prevalent MAP sensors respond indirectly by inferring airflow from changes in the behavior of the manifold. Hansen says the non-mechanical mass airflow sensors provide a more accurate direct measurement.

"Emissions control will work much better if you can directly sense how much air is coming into the engine," says Hansen. In addition to the use of micromachined silicon, thin-film and hot-wire sensor technologies may be the key to volume production of mass airflow sensors that will unseat the reigning MAP products, he speculates.

But according to Joe Staller, operations manager for Motorola's semiconductor products sector's sensor business, mass airflow sensors are nearly twice as expensive as MAP sensors. As a result, sensor-development partner Ford is putting them only on high performance vehicles.

Motorola's Van Tine sees a crucial test ahead for the growing market in accelerometers. "The basic make-or-break is whether you can incorporate self-test features so that the system can verify when the driver gets into the vehicle that the air bag is working," he says. He adds that Motorola is developing a silicon-based accelerometer and plans to sample it among test customers by midyear.

Hansen predicts that other applications—such as tire pressure, oil pressure, and air-conditioning sensors—will soon begin to pick up the slack for micromachined silicon pressure sensors. A specially designed EEPROM, for example, could measure not only oil level but could tell when engine oil had stopped working efficiently.



Although they can solve problems and add value, sensor failures have already caused costly headaches for car makers. In May 1989, Chrysler recalled 127,000 1984-model cars to repair an exhaust system sensor at no charge. If even half the car owners take Chrysler up on the offer, it could cost the company nearly $1 million.

Sensors are considered by some to be the weak link in automotive electronics, and many believe the weakness is in the packaging. Thermal stress can cause wire breakage and delamination of sensor materials. Hansen says improvements are needed in almost every aspect of the package, including better solders, increased use of surface-mount assembly, and rigid housings.

Environmental factors that drive the market can also have a limiting effect on technology. Heat is a growing problem in auto electronics, for example, since the growing number of components and the downsizing of engine compartments combine to reduce airflow. Hansen ascribes the reliance on the less-advanced variable-reluctance sensors in part because they can stand temperatures up to 200 degrees centigrade.

Meanwhile, U.S. auto makers' quality parameters for sensors are getting tougher; the acceptable defect level for a packaged sensor is well below 50 parts per million. That signals a change in the automotive electronics industry, where component tolerance levels traditionally have been fairly wide, says McGrath at PRTM. "But that's changing," he says. "Because of the environmental conditions in and around the car, these sensors have to be rugged."

Another breakthrough in reliability, he says, will come as manufacturers learn more about making the sensors and other information systems work together. The result, says McGrath, is a "vehicle area network" that works much like the local area computer networks used in corporate offices. Reliability, he said, will become a question of system failure, rather than component failure.

To simplify the network and streamline the tangle of wires linking controllers, sensors, actuators, and displays, manufacturers will have to rely heavily on multiplexing capability, requiring agreement on data-transmission standards—which is similar to the problem confronting computer-network market suppliers.

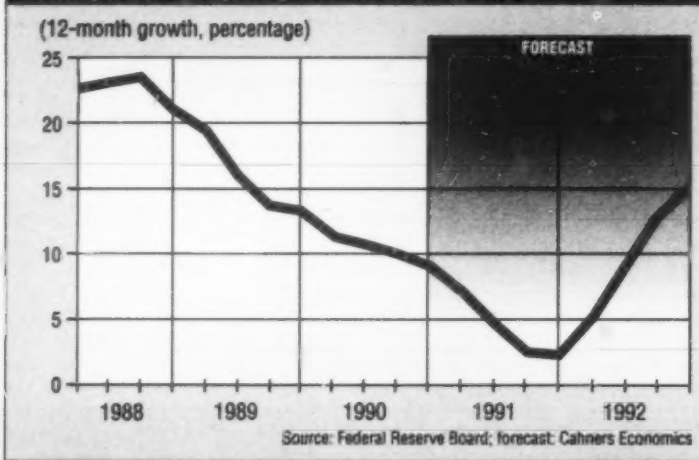
Concern about such issues is deep enough to prompt the Society of Automotive Engineers to form a special committee on multiplexing standards. Consultant Grace, who presented a paper on the subject to an SAE meeting last month, says the "one-wire" multiplexing issue will be a major one over the next five years.

Those issues even affect electronics companies that don't now make automotive sensors. In Chandler, Ariz., Fred Phail, strategic marketing manager for Intel Corp.'s automotive division, sees a growing role for the semiconductor industry as "smart" sensors become elements in a network, sharing data over a high-speed computer bus. But in another echo of the computer industry, Phail says auto makers and their suppliers will have to decide whether that bus will be 16- or 32-bit.

"The big question for the 1990s will be, 'How quickly does the electronic system become distributed rather than centralized?' " predicts Phail. "Software would have to make significant advances too, because of the need for redundancy in the system to keep the vehicle operating."

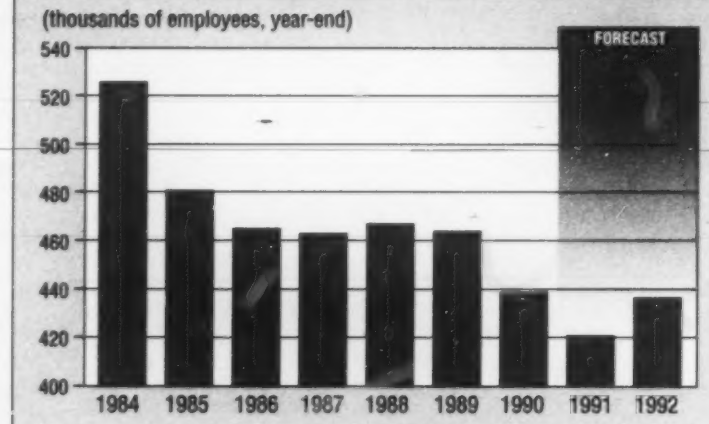
All in all, says McGrath with understatement, the evolution of electronic components into a control system "creates an interesting challenge for suppliers." □

Computer output growth dwindles...



Source: Federal Reserve Board; forecast: Cahners Economics

...so employment is cut back in 1991



Source: U.S. Department of Commerce; forecast: Cahners Economics

Computer payroll lowest since 1980

Government and company statistics have recently described a computer and peripheral equipment industry under extreme duress. Last winter, for example, U.S. factory production growth slowed to its lowest rate in 16 years; more recently, the Persian Gulf war sapped business confidence at a crucial juncture of the business cycle. But the truth remains that the industry has actually been slowing down and readjusting for some time in response to a weaker economy and a change in customer buying patterns.

A longer-term look at computer production growth shows that the rate of increase has been shrinking since August 1988. Even the last boom in 1988 was mild compared to the younger days of the industry. Consequently, the computer industry has been restructuring and purging its employment ranks. By the end of last year, U.S.-based computer and office equipment manufacturers employed only 439,300 workers—the smallest payroll since 1980.

Delivery times reflect the industry's weakness. According to *Purchasing* magazine, ELECTRONIC BUSINESS's sister publication, commercial buyers this past January waited an average of just 2.7 weeks for delivery of PCs. That's the shortest lead time since the survey began in 1985.

MADELINE FRANCHI

For more information on Cahners Economics' forecasting services, including seminars, newsletters, and database diskettes, contact Dan Buchan at (617) 630-2105, by fax at (617) 630-2100, or write Cahners Economics, 275 Washington St., Newton, MA 02158

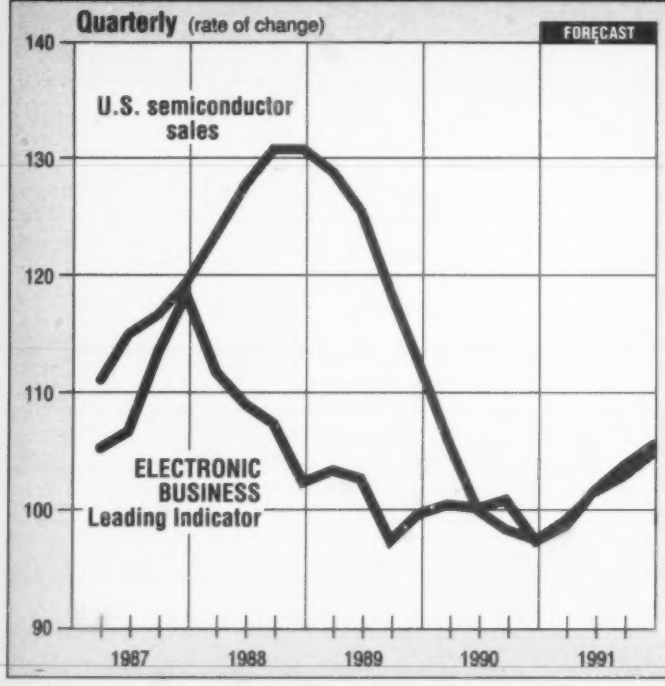
Computer market database

Latest quarter: 4th quarter 1989	Latest quarter	Previous quarter	Change	Year ago	Change	Next year	Change
Industrial production (SA,1987=100)	151.3	152.8	-1.0%	138.8	9.0%	159.9	5.7%
Shipments (SA, $ millions)	$18,233	$17,587	3.7%	$17,325	5.2%	$18,573	1.9%
New orders (SA, $ millions)	$16,967	$18,520	-8.4%	$17,506	-3.1%	$18,487	9.0%
Unfilled orders (SA, $ millions, end of qtr.)	$11,881	$13,147	-9.6%	$12,658	-6.1%	$12,130	2.1%
Inventory-to-shipment ratio (SA, end of qtr.)	1.91	2.04	—	2.11	—	1.97	—
All employees (thousands, end of qtr.)	439.3	441.0	-0.4%	464.6	-5.5%	421.3	-4.1%
Production workers (thousands, end of qtr.)	138.5	139.0	-0.4%	147.7	-6.2%	134.3	-3.0%
Business purchases (SAAR, $ billions)	$40.30	$39.73	1.4%	$40.76	-1.1%	$40.40	0.3%
Business purchases (SAAR, 1982 $ billions)	$128.54	$124.54	3.2%	$122.40	5.0%	$136.82	6.4%

SA = seasonally adjusted; SAAR = seasonally adjusted annualized rate; all other data is not seasonally adjusted
All data in current dollars, except where otherwise noted

Data sources: Federal Reserve Board, U.S. Bureau of the Census, and U.S. Bureau of Labor Statistics All data for SIC 357. Forecasts: Cahners Economics

ELECTRONIC BUSINESS Leading Indicator rebound begins this spring



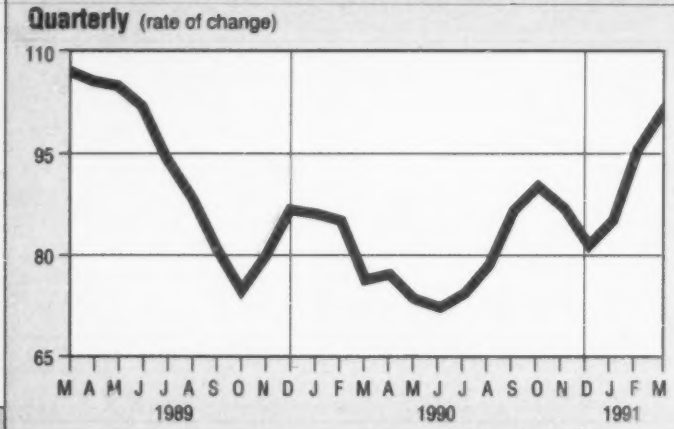
Spring marks rebound in Leading Indicator

The ELECTRONIC BUSINESS Leading Indicator (EBLI) took a positive step in February. Four of the six components of EBLI saw a healthy rise in early 1991, resulting in the long-awaited upturn.

Electronic components lead times offered the earliest signs of an imminent slowdown in the industry. From its last peak of 107.3 in March 1989, lead times growth slowed and then began to decline in July almost two years ago. Lead times sank to its lowest level of 72.3 in June 1990. Since then, lead times growth has been rising, with a slight break in the last two months of 1990, to a level of 101.8 in March. With the end of the war in the Persian Gulf, expect EBLI to continue to rise slowly to a forecasted peak of 106.6 in January 1992.

The ELECTRONIC BUSINESS Leading Indicator is a weighted composite of six statistics that tend to lead activity in the electronics industry. To obtain your complimentary background paper, contact Cahners Economics, 275 Washington St., Newton, MA 02158-1630, USA; telephone (617) 630-2119; fax (617) 630-2100.

Lead times for electronic components head up



Source: Electronics Purchasing

	Latest month	Previous month	Year ago	1990 average
ELECTRONIC BUSINESS Leading Indicator (rate of change, Feb.)	99.4	95.9	100.6	99.9
U.S. semiconductor bookings ($ millions, 3-month average, Feb.)	$1,272	$1,107	$1,218	$1,254
Weekly hours of semiconductor production workers (monthly average, Jan.)	39.7	40.9	40.2	40.4
Electronic components lead time index (1977 = 100, Mar.)	78.0	108.0	84.8	80.7
S&P's semiconductor stock price index (1970 =10, monthly average, Feb.)	70.3	59.6	61.9	64.6
Change in electronic components inventories ($ millions, SA, Jan.)	$33	-$15	-$4	$24
Contracts and orders for plant and equipment ($ billions, SA, Jan.)	$42.0	$44.9	$44.0	$42.1

SA = seasonally adjusted; all other data are not seasonally adjusted

Sources: Semiconductor Industry Association, U.S. Bureau of Labor Statistics, *Electronics Purchasing*, Standard & Poor's, U.S. Department of Commerce, U.S. Bureau of Economic Analysis